A Non-Cooperative Game for 3D Object Recognition in Cluttered Scenes

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Global approaches are hindered when used to match occluded models, in fact, only local properties are preserved in such scenarios.

On the other hand, local descriptor could fail to be distinctive enough to give an unambiguous match, or, when distinctive they tend to be less robust to noise.

We propose a Game-Theoretic approach that augments any local descriptor taking in account the pairwise spatial relations between keypoints.
Matching using Non Co-operative Games

- A large set of matching features (i.e. strategies) $S$ is selected with a standard technique (and some outliers are included);
- An initial population vector $\vec{x}$ (of size equal to the number of strategies) is initialized to some point of the standard simplex;
- A payoff $\Pi$ is defined for each pair of strategies, accordingly to some compatibility measure $\delta((a_1, a_2), (b_1, b_2))$ between them;
- The population is evolved through the following replicator equation:

  $$\vec{x}_i(t + 1) = \vec{x}_i(t) \frac{(\Pi \vec{x}(t))_i}{\vec{x}(t)^T \Pi \vec{x}(t)}$$

  We expect a population of highly mutually compatible strategies (i.e. matches) to survive! [1]
A Game-Theoretic Pipeline for Recognition

Rigid-Enforcing Compatibility

\[ \delta((a_1, b_1), (a_2, b_2)) = \frac{\min(|a_1 - a_2|, |b_1 - b_2|)}{\max(|a_1 - a_2|, |b_1 - b_2|)} \]

Matching Game

\[ S = \{(a, b) \in D \times M | b \in \text{dn}_k(a)\} \]
\[ \Pi = \{ \delta((a_1, b_1), (a_2, b_2)) \text{ if } a_1 \neq a_2 \text{ and } b_1 \neq b_2 \}
\text{ otherwise} \]

Segmentation Game

\[ S' = \{(a, b) \in D \times M | b \in \text{en}_k(a)\} \]
\[ \Pi' = \{ \delta((a_1, b_1), (a_2, b_2))^\alpha \text{ if } a_1 \neq a_2 \}
\text{ otherwise} \]
An Example of the Evolutionary Process

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<tr>
<th></th>
<th>A1</th>
<th>B2</th>
<th>C3</th>
<th>D4</th>
<th>D5</th>
<th>E6</th>
<th>E7</th>
<th>F8</th>
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Density vs. Iterations
Comparisons with other approaches show that our method (used with SHOT descriptor) performs well also with relevant occlusion.

An accurate analysis of the contribution of each part of the pipeline shows that all of them are required to make it effective.
Thank you for your attention!

Please ask me any question you might have and...

... do not forget to come and follow us at our tutorial at CVPR 2011!

Game Theory in Computer Vision and Pattern Recognition
June 20th 2011 - Colorado Springs, Colorado, USA

[1] Andrea Albarelli, Emanuele Rodolà, Andrea Torsello
A Game-Theoretic Approach to Fine Surface Registration
(CVPR2010), San Francisco, USA, June 2010

Loosely Distinctive Features for Robust Surface Alignment
(ECCV 2010), Heraklion, Greece, September 2010